ESTIMATING FLOW RATE IN GAUGED AND UNGAUGED STATION IN KUANTAN RIVER BASIN USING CLARK METHOD IN HEC-HMS

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Anggaran kadar alir dengan menggunakan simulasi hidrologik yang melibatkan model komputer adalah merupakan teknologi yang canggih dan cara ini mampu untuk meningkatkan pemahaman dan memberikan hasil yang lebih dipercayai. Pada masa kini, disebabkan oleh sumbangannya yang tidak dapat dinafikan, ia menjadi alat yang sangat diperlukan untuk mereka bentuk sebarang pendekatan pengurusan air ekologi yang mampan. 'US Army Corps of Engineers' telah mengambil inisiatif untuk membangunkan model yang stabil, HEC-HMS yang boleh digunakan untuk pelbagai simulasi hidrologi. Nilai parameter yang diperlukan untuk menyelesaikan simulasi pada asasnya bergantung kepada kaedah yang dipilih untuk kehilangan, mengubah dan aliran asas. Input data yang boleh dipercayai dan tepat diperlukan untuk memeriksa kesesuaian model untuk kawasan lokasi kajian dan tujuan penyelidikan jika tiada proses calibrate dan validasi.Walau bagaimanapun, dalam kajian ini, parameter model telah diubah dan penentukuran model dilakukan secara berasingan untuk ketiga-tiga kaedah terpilih, 'Soil Conservation Service Curve Number' bagi kaedah kehilangan, 'Constant Monthly' bagi kaedah aliran asas dan Clark Unit Hydrograph bagi kaedah transform untuk menentukan nilai parameter bagi simulasi yang paling sesuai dalam usaha untuk mendapatkan kadar aliran yang paling tinggi di setiap kawasan lembangan di Lembangan Sungai Kuantan. Langkah yang diambil setelah model yang dikalibrasi diperolehi adalah untuk menjalankan proses pengesahan untuk mengesahkan model hidrologi dan memastikan ia boleh digunakan untuk set hujan dan data aliran lain di kawasan itu untuk kejadian ribut hujan yang berlainan. Untuk setiap aliran yang disimulasi untuk proses pengesahan dan penentukuran, indeks Nash-Sutcliffe (NSE) digunakan sebagai kriteria untuk membandingkan hasil antara hidrograf daripada data asal dan simulasi. Model yang boleh diterima mempunyai rangkaian NSE di antara 0.8 hingga 1.0. Lebih dekat nilai NSE kepada 1, semakin tinggi keseragaman hidrograf simulasi dan data asal. Dalam proses penentukuran pertama, nilai NSE yang diperolehi adalah 0.81 untuk kejadian ribut pada 4 September 2010, nilai ini menunjukkan bahawa model itu dilakukan dengan baik dan cukup baik untuk digunakan. Untuk mengesahkan model yang dikalibrasi sebelum ini, proses pengesahan dilakukan dengan menggunakan set data aliran hujan dan aliran data yang berbeza dari proses penentukuran. Peristiwa hujan lebat pada 12 Oktober 2013 telah digunakan dan nilai NSE yang dikeluarkan adalah 0.91. Sebagai kaedah transformasi yang dipilih dalam kajian ini, Clark Unit Hydrograph menyelaraskan aliran dengan jayanya dan nilai parameternya mudah dan senang untuk dipenuhi. Oleh itu kaedah Clark Hydrograph dapat disyorkan sebagai kaedah transformasi terbaik untuk Lembangan Sungai Kuantan dengan 'Soil Conservation Service Curve Number' sebagai kaedah kehilangan. Oleh kerana terdapat banyak sungai yang tidak mempunyai rekod data kadar aliran yang terletak di Lembangan Sungai Kuantan, pendekatan ini boleh digunakan untuk mensimulasikan aliran sungai di kawasan-kawasan lain dengan ciri yang sama dan juga pendekatan penentukuran dan pengesahan yang sama boleh digunakan di bahagian lain kawasan tropika.

ABSTRACT

Estimating flow rate by using hydrologic simulation engaging computer model is at the cutting edge of ways to boost the understanding and provide further reliable outcomes. Nowadays, due to its undeniable contribution, it has become indispensable tools to design any ecologically sustainable water management approaches. US Army Corps of Engineers has taken an initiative to develop a stable and dependent model, HEC-HMS that could be used for many hydrological simulations. The value of parameter needed in order to complete the simulation basically depends on the method chosen for loss, transform and base flow. Reliable and precise data inputs needed to check suitability of the model for the study location area and the purpose of the research if there is no any calibrate and validate process. However, in this study, the model parameters were changed and the model calibration was performed separately for the three selected methods, the Soil Conservation Service Curve Number loss method, the Constant Monthly base flow and the Clark Unit Hydrograph for transform method to determine the most suitable simulation and to obtain the highest peak discharge for every sub basin in Kuantan River Basin. The step taken after obtaining the calibrated model is to run the validation process to validate the hydrologic model and ensure it can be used for other set of rainfall and flow data in that area for different event of rainstorms. For every flow simulated for validation and calibration process, the Nash-Sutcliffe index (NSE) was used as a criterion to compare the outcomes between observed and simulated hydrograph. The acceptable model has a range of NSE in between 0.8 to 1.0. Simply saying, the closer the value of NSE to 1, the higher the similarity of the simulated and observed hydrograph. In the first process of calibration, NSE value obtained is 0.81 for the rainstorm event of 4th September 2010, this value shows that the model is well performed and good enough to be used. In order to validate the calibrated model before, validation process was done using different data set of rainfall and stream flow from calibration process. Rainstorm event of 12th October 2013 was used and the value of NSE produced is 0.91. As the chosen transformation method in this study, Clark Unit Hydrograph simulates the flows successfully and the parameter value is easy and simple to be fulfilled. Therefore, the Clark Unit Hydrograph method could be recommended as the best transformation method for the Kuantan River Basin with the SCS Curve Number as the loss method. As there are plenty of ungauged rivers located in the Kuantan River Basin, this approach can reliably be applied in order to simulate river flows in the other areas with same characteristic and also the same approach of calibration and validation can be applied in other parts of the tropics.

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LIST OF SYMBOLS

A	Area of catchment involve
S	Average slope of that watercourse
L	Longest watercourse length in the watershed
Tc	Time of concentration
R	Storage coefficient
CN	Curve Number
Q_B	Baseflow
A_i	Area for *i*th land use type
CN_i	Curve Number for *i*th land use type
Y_i^{obs}	*i*th observed data
Y_i^{sim}	*i*th simulated data
Y_i^{mean}	Mean of observed data
n	Total number of observation data

LIST OF ABBREVIATIONS

KRB	Kuantan River Basin
DID	Department Of Irrigation And Drainage
HEC-HMS	Hydrologic Engineering Center- Hydrologic Mdelling System
GIS	Geographical Information System
ARI	Average Recurrence Interval
SWM	Southwest monsoon
NEM	Northeast monsoon
JUPEM	The Department Of Survey And Mapping Malaysia
LAT	Latitude
LONG	Longitude
DEM	Digital Elevation Model
SCS CN	Soil Conservation Service Curve Number
NSE	Nash-Sutcliffe index
WCN	Weighted Curve Number

CHAPTER 1

INTRODUCTION

1.1 Background of study

Flood events are often catastrophic leads to damages of physical and social life. From the past decades, increasing flood incidences have been observed due to variations in rainfall patterns, change climate condition. One of the main factors for occurring flood is rapid development in urban sector. Malaysia is vulnerable to flood for being its geographic location in the tropical region. The east coast part of Malaysia's flood often experiences flooding during the northeast monsoon season.

Kuantan is one of the flood vulnerable areas of peninsular Malaysia. Kuantan River Basin (KRB) is the important watershed passing through Kuantan. This basin is accountable for bring flood during the wet season by perceiving heavy rainfall fall resulting the spilling over the flow that inundate flood plain or low-laying areas causing intensified damages in terms of commercial, residential properties, roads, infrastructure, irrigation network. However, rapid development in river catchment also be responsible to produce high runoff and worsened river capability. Therefore, leads to increasing flood frequency and magnitude. According to Department of Irrigation and Drainage Malaysia (DID)'s flood reports, 2001/02, 2012/13 were the worst flood. Kuantan is expected to be worst since 1971 due to receive unexpected heavy rainfall, high tide in upstream and downstream (Zaidi et. al, 2014).

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1.2 Problem Statement

KRB has been chosen as study area. The important river of Pahang start from Sg. Lembing passing through Kuantan City and drained in to South China Sea. It covers an area of 1630km^2. The elevation range is from 0 at the mouth of watershed to 1511m in the remotest part of north-west watershed. KBR contains of several main tributaries, which drain the rural, agricultural, urban and industrial areas of Kuantan (Nasir et. al, 2012).

Since the past decades, KRB has history of experiencing the flood due to its tropical climatic condition. Inundation rain brings about spilling over of river surface runoff submerged low laying areas hampered human social and economic life. After 30 years of disastrous flood in 1971, the year 2001/02 experienced havoc flood with magnitude of 3.9 brought by continuous heavy rainfall during the northeast monsoon which hit most of the part of Peninsular Malaysia. Pahang was submerged under water after nearby rivers overflowed affected 18,000 people and 22,940km^2 of land (EKA, 2002). Right after 10 years, another worst flood condition in years 2011/12 crippled Kuantan. Sudden flood due to continuous massive rainfall affected relatively 6,000 flood victim reportedly; several roads were badly flooded, and hundreds of vehicles trapped in resulting of the poor drainage system that did not cope hefty rain (Kuala Lumpur Post, 2012). The unforeseen massive flood, recently in 2013 experienced due to prolonged heavy rainfall and land-use change brought serious peril to society, especially to low laying areas in Kuantan. Kuantan was severely afflicted. Around 14,044 people were evacuated and major damages occurred in terms of electricity, road's structure, buildings and belongings thus government suffered with significant financial cost for repairing flood damages (Jamaludin et. al, 2013). Torrential rain caused rise in level of river basin resulting increased outflow discharge.

In order to improvise the situation and prepared for an upcoming abrupt natural catastrophe, modelling system using HEC-HMS is designed to simulate hydrological data and precipitation run-off processes of watershed systems by cause of commonly used in a wide range areas.

1.3 Objective

To ensure this study is successful, two objectives have been determined. Both these objectives works as a guide line so that the outcomes of this study can be easily achieved. The objectives are:

a) To analyse hydrological data for gauged and ungauged station in Kuantan River Basin

b) To estimate the flow rate for every sub catchment area in Kuantan River using HEC-HMS

1.4 Scope of Study

The scopes of study have been determined in order to ensure that literature study is focusing on certain fields only. The limitations of this study are listed below:

1. Study area: The study area is focused on Sg Kuantan catchment area.

2. Simulation: The method used is simulating the river using gathered data from local authorities. A river network was established using Google satellite images data and GIS software. The analyses then were carried out using HEC-HMS. The simulating process was conducted to estimate the flow rate at out flow and compare with the stream flow data.

3. Method: Clark Unit Hydrograph was used for Transform Method and a simulation using 2, 5, 10, 20, 50 and 100 years of design rainfall (ARI) are done to obtain the peak discharge.

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